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(54) Title: METHOD FOR PREPARING HIGH OIL CONTENT FISH FEED PELLETS

(57) Abstract

Provided is a method for preparing high oil content fish feed pellets. The method comprises extruding a mixture of basic components for forming the matrix of fish feed pellets together with an additive which is solid under ambient conditions into porous pellets. The additive is a lipid or a fatty acid. Oil is then absorbed into the thus formed porous pellets to prepare the high oil content fish feed pellets. It is preferred that the additive is either a hydrogenated oil derived from animal or plant origin, or a lipid emulsifier such as a mono–, di– or tri–glyceride. The resulting pellets, which may include up to 50 % by wt. of oil, suffer very little oil leakage during storage and in use.

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METHOD FOR PREPARING HIGH OIL CONTENT FISH FEED PELLETS

The present invention is directed to a method for preparing high oil content fish feed pellets, and in particular such pellets which contain up to 50% by weight of oil and from which only minor amounts of oil leak during storage and use.

Fish farming is an increasingly thriving industry in many parts of the world. Fish feed for farmed fish is usually produced in the form of pellets which contain a combination of components which satisfy the nutritional requirements of fish. One of these requirements is that the feed includes a source of energy and this may be present in the feed as proteins, carbohydrates, oils or any combination thereof. In general, oils are included as at least one of the energy sources because they are nutritionally excellent, are readily available and are relatively inexpensive compared to the alternative energy sources.

The oils presently used are liquid at ambient temperature. If a significant quantity of oil is included in the feed components prior to their extrusion into pellets, then the oil interferes with the extrusion process and gives pellets possessing relatively low strength. On the other hand, if the oil is applied to pre-formed porous pellets of the usual type, then it is found that the oil leaks out of the pores both during storage and in use when the feed is immersed in water. This is disadvantageous because both the energy content of the feed diminishes and because the oil which leaks out both pollutes and can cause feed-handling equipment to malfunction.

At present, there is a demand from fish farmers for fish feeds having an ever increasing energy content. Accordingly, feed manufacturers are striving to prepare feeds having an oil content of 30% by weight or more, but such high oil content feeds suffer significantly from the problem of oil leakage.

Various solutions to the problem of oil leakage have been proposed. Thus, JP-A-3-108 454 proposes to mix in an extruder the conventional components for forming fish feed pellets in combination with both a glycerol fatty acid ester and 10-50 wt.% of oil to produce feed pellets having a fat and oil content of up to 50% by wt. However, it has since been found that adding both the glycerol fatty acid ester and a relatively high content of the oil to the feed formulation prior to its extrusion can lead to difficulties in the extrusion step, produces pellets of poor integrity and in any event does not entirely solve the problem of oil leakage. In a similar vein, it has been proposed in WO 95/07028 to treat pre-extruded pellets with a heated mixture of a fish oil and a lipid which is solid at ambient temperature. It is taught that this mixture cools within the pores of the pellets to form a crystalline structure in which the oil becomes trapped. It has been found that the resulting pellets still suffer to some extent from the problem of oil leakage.

It is an object of the present invention to provide a method for preparing high oil content fish feed pellets which have a reduced tendency to leak oil compared to pellets presently available, and in particular those produced according to the prior art acknowledged above.

According to a first aspect, the present invention provides a method for preparing high oil content fish feed pellets comprising the steps of:

(i) extruding a mixture comprising:

(a) components for forming the matrix of fish feed pellets including a source of carbohydrate and/or a source of protein, and

(b) an additive which is solid under ambient conditions selected from a lipid and a fatty acid;

to form porous pellets, and

(ii) absorbing oil into the porous pellets to prepare the high oil content fish feed pellets.

The components for forming the matrix of fish feed pellets are those conventionally used, and in particular include a source of carbohydrate and/or a source of protein. Preferably, the components contain a source of both carbohydrate and protein. Examples of such components include meal such as fish meal, soya meal or meat meal; cereals such as wheat, gluten meal or corn. Starch may also be included in the form of modified starch adapted to act as a binder. The components also usually include vitamins and minerals nutritionally required by the fish.

The above matrix components are mixed with an additive which is solid under ambient conditions, that is a pressure of about 0.1 MPa and a temperature of about 20°C. The additive is a lipid or a fatty acid. Suitable lipids include hydrogenated oils of animal or plant origin such as hydrogenated fish oil, hydrogenated soya oil, hydrogenated sunflower oil or hydrogenated palm oil. The lipid may also be

a lipid-type emulsifier, such as a mono-, di- or tri-glyceride. One such suitable lipid emulsifier is glycerol monostearate. Suitable fatty acids include stearic or palmitic acids.

The matrix components and the additive are mixed such that the resulting mixture preferably includes 0.1-10% by wt. of the additive, more preferably 1-6% by wt. and most preferably 1.5-4% by wt.

Prior to extrusion, the mixture may be subjected to conventional pre-conditioning. In pre-conditioning, the dry components of the feed and the liquid components, either heated or at ambient temperature, are separately introduced into a pre-conditioning device where they are continuously mixed, heated and moisturised by injection of hot water and/or steam. The intense mixing of water and steam added to the dry feed during pre-conditioning initiates cooking of the feed components. Pre-conditioners have been utilised in the production of fish feed pellets for many years. Most pre-conditioners contain one or two mixing/conveying elements which consist of rotating shafts with radially attached pitched paddles. The apparatus used for pre-conditioning includes atmospheric or pressurised chambers.

If pre-conditioning is used, then typical temperatures adopted lie in the range 75-95°C. Moisture is added to the components in an amount of 5-30% by wt. of the dry feed components entering the pre-conditioner. It is also possible to add a small content of oil, such as fish oil, into the chamber of the pre-conditioner. In this case, the oil may preferably be added in an amount of 0.5-20% by wt., more

preferably 1-10% by wt. and most preferably 2-5% by wt, based upon the dry weight of the other feed components fed into the pre-conditioner.

The optionally pre-conditioned mixture is then extruded to form porous pellets. The mixture is directed into an extruder assembly which consists of a barrel segment and a screw. It is here that the major transformation of the raw or pre-conditioned formulations occurs which ultimately affects final product characteristics. Extruders employed in fish feed manufacture are generally classified as being of a single or twin screw design. In both designs, the impact of final product characteristics is affected by screw and barrel profile, screw speed, processing conditions such as temperature and moisture content, raw material characteristics and die/knife selection. Appropriate selection of an extruder and extruding conditions is well known to one skilled in this technical art. If the mixture has not been pre-conditioned, then liquids such as water, steam or oil are added directly into the extruder barrel. If oil is added to the mixture at this stage, then this is in the amounts as previously mentioned in connection with pre-conditioning. It is also possible to add a proportion of the oil into both the pre-conditioner and the extruder such that the total added amount lies in one or more of the ranges mentioned above.

In the resulting porous pellets, it is believed that the lipid or fatty acid additive forms oil receptive lipophilic structures with the carbohydrate and/or proteinaceous components present in the basic dry feed mixture. It is these structures which later attract and hold the oil absorbed into

the porous pellets in the subsequent step of oil absorption.

The extruded pellets have a density of about 200-800 g/cm^3, preferably about 500 g/cm^3. Such pellets preferably have an average pore size of 10-50 µm and more preferably about 20-40 µm.

In a subsequent step, oil is absorbed into the porous pellets to prepare the high oil content fish feed pellets of the present invention. The oil may be a single compound or a mixture of individual oil compounds. In particular the oil may be fish oil such as menhaden oil, herring oil or capelin oil.

In the step of absorbing oil into the porous pellets, 1 part by weight of the porous feed pellets are mixed with 0.05-1.0 parts by weight of the oil, preferably 0.1-0.5 parts by weight and most preferably 0.3-0.45 parts by weight. This amount is suitably adjusted according to the desired oil content of the resulting fish feed pellets.

The extruded feed pellets may be loaded with oil immediately after extrusion, or may be stored for some time prior to the oil loading step. The loading of the feed pellets with the oil can be carried out by mixing, dipping, spraying, coating or any other means. For example, loading can be carried out by subjecting the feed pellets and oil to rotary mixing in a drum under normal pressure, but the operation can also be carried out under elevated or reduced pressure.

In a preferred aspect of the present invention, the loading is carried out at below ambient pressure and in particular by vacuum coating as described in any of DE-A-2 933 261, EP-A-0 556 883 or GB-A-2 232 573. The loading methods described in these publications are incorporated herein by reference. Such methods are preferred as they enable relatively high amounts of the oil to be loaded and absorbed by the feed pellets. Thus it is preferred that the extruded pellets are first subjected to reduced pressure and then simultaneously or subsequently the pellets are contacted with the oil. The pressure applied during this step is around 1-50kPa, preferably 10-30kPa. The loading step of absorbing oil in the pellets is carried out for 30 seconds-30 minutes, more preferably 1-5 minutes. Commercial apparatus is readily available which is suitable for this step, and a specific example is the apparatus sold under the Trade Mark "Vario Vac" manufactured Dorit Maschinen Handels AG. After carrying out the absorption of the oil into the porous pellets under reduced pressure, the pressure is returned to ambient pressure. This increase in pressure forces the oil into the interior of the porous feed pellets.

In one particularly preferred aspect of the present invention, the step of vacuum coating the porous pellets with oil is repeated one or more further times in order to adsorb further oil into the pellets. In this case, the individual vacuum coating steps may be carried out in the same way. Between the vacuum coating steps, the atmosphere may be returned to atmospheric pressure although it is also possible to increase it to less than atmospheric pressure before applying the second or even a subsequent vacuum coating step.

Coating of oil is carried out such that the resulting fish feed pellets contain a total of 10-50 % by wt. of oil, more preferably 20-50 % by wt. of oil and most preferably 30-40 % by wt of oil.

Detailed crystallographic analysis of the resulting pellets has revealed that there are no crystal structures formed between the additive and the oil. Accordingly, the mechanism of the trapping of the liquid oil in the pellets provided by the present invention is clearly fundamentally different from that relied upon in the pellets produced in accordance with WO 95/07028.

According to a further aspect, the present invention provides high oil content fish feed pellets obtainable by the method previously described. Further, a method is also provided for farming fish comprising preparing high oil content fish feed pellets as described above and then feeding such pellets to fish. The fish feed pellets provided by the present invention can be fed to any type of farmed fish including yellowtail, sea bream, halibut, yellow jack, carp, trout, eel, cat fish, or most preferably salmon.

The high oil content fish feed pellets provided by the present invention have lower levels of oil leakage than previously available fish feeds, and in particular lower levels than fish feed pellets produced according to the methods of JP-A-3-108 454 and WO 95/07028. Accordingly, the pellets provided by the present invention are advantageous in that they suffer very little oil loss during storage and in use which means that they are both economically and environmentally advantageous.

The invention will now be described in more detail according to the following Examples and Comparative Examples which should not be considered to limit the scope of the appended Claims.

Examples

Fish feed pellets A-E were prepared having the following formulations

FEED A (Comparison)

Ingredient	Feed %
Fishmeal	47.5
Soya Meal	8
Cereals (wheat/suprex corn)	10
Binder (Modified Starch)	2
Vitamins	0.5
Minerals	2
Fish oil	30

FEED B (Comparison)

Ingredient	Feed %
Fishmeal	47
Soya Meal	8
Cereals (wheat/suprex corn)	10
Binder (Modified Starch)	2
Vitamins	0.5
Minerals	2
Hydrogenated Rapeseed Oil	0.8
Fish oil	29.7

FEEDS C-E (Invention)

Ingredient	Feed %
Fishmeal	47.5
Soya Meal	8
Cereals (wheat/suprex corn)	7
Binder (Modified Starch)	2
Vitamins	0.5
Minerals	2
Glycerol Monostearate	3
Fish oil	30

Each of the feeds A-E was prepared by mixing the basic components including meal, cereals, binder, vitamins and minerals together with 3% by wt. of fish oil based upon the total weight of the mixture. Further, in the case of Feeds C-E, 3% by wt. of glycerol monostearate was added together respectively with 3, 5 or 8% by wt. of fish oil into the pre-conditioning unit. The feeds were then pre-conditioned at a temperature of about 85°C together with 18% by wt. water based upon the weight of dry feed mix entering the pre-conditioner. The pressure applied during pre-conditioning was about 0.25 MPa.

The pre-conditioned mixture was then extruded using a Wenger TX-57 twin screw extruder operating at 325 kg/hr with the addition of further steam and water. The resulting pellets had a diameter of 9 mm, a length of 11 mm and were roughly cylindrical in shape. The resulting extruded pellets, containing approximately 22% by wt. of moisture, were then passed through a dryer where the moisture content was reduced to approximately 7% by wt.

The extruded pellets were then vacuum coated with oil by firstly applying a vacuum of around 20 kPa to the pellets, spraying fish oil on the pellets, releasing the vacuum to atmospheric pressure then repeating these steps in a second vacuum coating step. After the second vacuum coating step, the pellets are ready for use. In the case of Feed B, the oil was applied as a heated mixture in combination with 3% by wt. of the mixture of hydrogenated rapeseed oil in accordance with the teaching of WO 95/07028. It has been found that inclusion of greater amounts of hydrogenated rapeseed oil in the oil mixture does not lead to any greater anti-leakage effect in the final pellets. Thus addition of 3% by wt. of the hydrogenated rapeseed oil (equivalent to 0.8% by wt. in the final pellets) has been found to provide optimum results within the teaching of WO 95/07028.

The extent of oil leakage from each of the Feeds A-E was then measured by the following method. Firstly, about 5 g of the Feed being tested were placed on a filter paper in a Petri dish. In order to simulate the effect of bag storage, 150 g weight was then placed on an upturned Petri dish lid resting on the pellets. The dishes were then placed overnight in a heat cabin at 40°C. Simultaneously, a control dish with filter paper only was prepared in order to measure and compensate in the leakage calculations for the weight loss from the filter paper due to moisture evaporation. Leakage was then calculated based upon the increase in weight of the filter paper as a percentage of the initial weight of the feed pellets taken.

The following Table sets out the results of the oil leakage tests applied to Feeds A-E

Table

Sample Description						Analysis	Leakage	
Feed	% by wt GMS[1] added to the dry mix	% by wt fish oil added to the dry mix	% by wt fish oil added in the pre-conditioner	% by wt fish oil added by vacuum coating	% by wt HRO[2] included in the oil coating mixture	Fat content of final pellets in % by wt	% by wt of oil which leaked from pellets during test	Relative %
A	0	3	0	27	0	34.3	39.5	100
B	0	3	0	27	3	35.1	25.5	65
C	4	3	3	24	0	36.1	15.4	39
D	4	3	5	22	0	35.7	4.1	10
E	4	3	8	19	0	35.9	5.4	13

GMS[1] is Glycerol Monostearate
HRO[2] is Hydrogenated Rapeseed oil

It will be seen from the results above that Feed A which includes no additive looses over 39% by wt. of the absorbed oil. In comparison, the Feed B formulated generally in accordance with WO 95/07028 looses only around 25% by weight of its oil. On the other hand, the Feeds C-E formulated in accordance with the present invention leak significantly less oil, and in particular feeds in which oil is added to the pre-conditioner have extremely low levels of oil leakage compared to the Comparative Feeds A and B. Such relatively low levels of oil leakage could not have been predicted on the basis of the prior art.

CLAIMS:

1. A method for preparing high oil content fish feed pellets comprising the steps of:

(i) extruding a mixture comprising:

(a) components for forming the matrix of fish feed pellets including a source of carbohydrate and/or a source of protein, and

(b) an additive which is solid under ambient conditions selected from a lipid and a fatty acid;

to form porous pellets, and

(ii) absorbing oil into the porous pellets to prepare the high oil content fish feed pellets.

2. A method according to Claim 1, wherein the components for forming the matrix comprise one or more of meal, cereal and starch.

3. A method according to Claim 1 or Claim 2, wherein the additive is a lipid selected from hydrogenated rapeseed oil, hydrogenated fish oil, hydrogenated soya oil, hydrogenated sunflower oil and hydrogenated palm oil.

4. A method according to Claim 1 or Claim 2, wherein the additive is a lipid emulsifier selected from a mono-, di- or tri-glyceride.

5. A method according to Claim 1 or Claim 2, wherein the additive is a fatty acid selected from stearic acid and palmitic acid.

6. A method according to any preceding Claim, wherein the mixture extruded in step (i) comprises 0.1-10 % by wt. of the additive.

7. A method according to Claim 6, wherein the mixture extruded in step (i) comprises 1-6 % by wt. of the additive.

8. A method according to any preceding Claim, wherein the mixture extruded in step (i) further comprises 0.5-20 % by wt. of oil.

9. A method according to any preceding Claim, comprising absorbing sufficient oil into the porous pellets in step (ii) so that the fish feed pellets contain a total of 10-50 % by wt. of oil.

10. A method according to any preceding Claim, wherein the oil is a fish oil.

11. A method according to any preceding Claim, comprising absorbing the oil into the pellets in step (ii) by vacuum coating.

12. A method according to Claim 11, wherein the vacuum coating of the oil into the pellets is carried out two or more times.

13. High oil content fish feed pellets obtainable by a method according to any preceding Claim.

14. A method for farming fish comprising preparing high oil content fish feed pellets according to Claims 1-12, and feeding the pellets to fish.

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(54) Title: METHOD FOR PREPARING HIGH OIL CONTENT FISH FEED PELLETS

(57) Abstract

Provided is a method for preparing high oil content fish feed pellets. The method comprises extruding a mixture of basic components for forming the matrix of fish feed pellets together with an additive which is solid under ambient conditions into porous pellets. The additive is a lipid or a fatty acid. Oil is then absorbed into the thus formed porous pellets to prepare the high oil content fish feed pellets. It is preferred that the additive is either a hydrogenated oil derived from animal or plant origin, or a lipid emulsifier such as a mono–, di– or tri–glyceride. The resulting pellets, which may include up to 50 % by wt. of oil, suffer very little oil leakage during storage and in use.

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INTERNATIONAL SEARCH REPORT

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PCT/EP 98/02503

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 A23K1/16 A23K1/18

According to International Patent Classification(IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
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Documentation searched other than minimumdocumentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
P,X	WO 97 42836 A (AQUATIC FEEDS APS ;BECK LAURITZEN PETER (DK)) 20 November 1997 see page 7, line 6 - line 18 see page 8, line 28 - page 9, line 15 see page 10, line 18 - page 11, line 17 see examples 1-3 see claims 1,5,14	13,14
Y	GB 2 232 573 A (CANADA PACKERS INC) 19 December 1990 cited in the application see page 3, line 33 - page 5, line 29 see examples 1-5 see claims 1-8,11-14	1,13,14
A		9-12

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document. with indication.where appropriate. of the relevant passages	Relevant to claim No.
Y	PATENT ABSTRACTS OF JAPAN vol. 015, no. 297 (C-0854), 29 July 1991 -& JP 03 108454 A (DAI ICHI KOGYO SEIYAKU CO LTD), 8 May 1991 cited in the application see abstract	1,13,14
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A	WO 95 07028 A (BP NUTRITION ARC ;LADSTEIN KIRSTI (NO); THORSEN FRED (NO)) 16 March 1995 cited in the application see page 2, last paragraph - page 6, paragraph 1 see claims 1-5	1,13,14
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